

## "APPARATUS AND METHODS FOR TWIN SHEET THERMOFORMING"

### Field of the Invention

5 This invention relates apparatus and methods for twin sheet thermoforming and in particular to improved methods and apparatus for removing seams from formed articles.

### Description of the Prior Art

10 Twin sheet thermoforming is increasingly proposed for the formation of large articles, in applications such as refrigerator cabinets, and other appliance cabinets have been envisaged, for example in US Patent 5,374,118. In that patent it is suggested that the removal of the seam and the flange may be accomplished in the mould cavity by an independently actuated knife positioned in a channel in one mould half immediately adjacent the mould cavity. A part thermoformed and trimmed in this manner inevitably  
15 has less strength at the weld as there is no pinch-off region on the mould halves adjacent the mould cavity, and consequently the weld (if the flange is trimmed right up against the part to eliminate further processing) is weak.

In general for strong welds a significant compression of the material in the pinch-off region is desirable to induce significant plastic displacement into the region of the  
20 weld, usually manifesting as a fillet on the inside thereof. This necessarily requires provision of opposed surfaces on opposed mould halves in the pinch-off region to achieve the necessary compression, eliminating the ability to locate cutting apparatus such as the knives of the above-mentioned US Patent. Consequently articles formed in this manner generally are removed from the mould with the flange still attached, the  
25 flange and seam being subsequently machined off. This clearly adds further labour or capital-intensive steps to the manufacturing process and can also impinge on the aesthetic appeal of the article.

### Summary of the Invention

30 It is therefore an object of the invention to provide apparatus and/or methods for twin sheet thermoforming which goes some way towards overcoming the above

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disadvantages or which will at least provide the public with a useful choice.

In a first aspect the invention consists in a mould for twin sheet thermoforming wherein one of the mould halves includes a retractable pinch-off region, which is able to retract relative to the remainder of said mould half upon application of a force thereto greater than a predetermined force, such that the remainder of the mould half may cooperate with the second mould, on further closing, half to shear off the seam of a thermoformed article.

In a second aspect the invention consists in a mould for twin sheet thermoforming including a pinch-off region substantially as herein described in accordance with and as illustrated by the accompanying drawings.

In a third aspect the invention consists in a method for producing a pre-trimmed twin sheet thermoformed article wherein a pair of mould halves are brought together to join respective sheets in a pinch-off region, and to cause significant thickness reduction in the pinch-off region, and subsequently causing the pinch-off region of one said mould half to retract relative to the rest of said mould half, to thereby allow said mould halves to close further, and closing said mould halves further to cooperate to cut off the seam of the thermoformed article.

In a fourth aspect the invention consists in a method for producing a pre-trimmed twin sheet thermoformed article substantially as herein described with reference to and as illustrated by the accompanying drawings.

In a fifth aspect the invention consists in an article formed by method and/or apparatus according to any one of the preceding paragraphs.

To those skilled in the art to which the invention relates, many changes in construction and widely differing embodiments and applications of the invention will suggest themselves without departing from the scope of the invention as defined in the appended claims. The disclosures and the descriptions herein are purely illustrative and are not intended to be in any sense limiting.

### **Brief Description of The Drawings**

The preferred form of the present invention will now be described with reference to the accompanying drawings in which;

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Figure 1 is a cross-sectional elevation through one side of a twin sheet thermoforming mould according to the present invention,

Figures 2a - 2c are close up views of the pinch-off region of the mould of Figure 1, including the region encircled by circle A, in different stages of the trimming process, in Figure 2a with the part formed but the seam not yet compressed, in Figure 2b with the seam compressed to provide weld reinforcement, and in Figure 2c with the upper mould half depressing the pinch off member of the lower mould half to shear the seam from the part, and

Figure 3 is a cross-sectional elevation through the edge region of a mould half showing detail of one embodiment of the pinch off member and its retention in the mould half.

#### **Detailed Description of the Preferred Embodiments**

With reference to Figure 1, that area of a thermoforming mould is shown in cross-section where the joining of the twin sheets occurs at a pinch-off region 1. In the thermoforming process the twin sheets, which are initially planar and parallel and mounted for example on supporting frame 2, are formed and joined by the action of the mould halves 3, 4 in the direction of arrows 5, 6 and assisted by suction in the mould cavity or internal pressure between the sheets or both. These aspects of the thermoforming process are well known in the art and do not form part of the invention.

Referring to Figure 2a, the mould halves 3, 4 are brought together, stretching and forming the sheets 7, 8 until the sheets meet at the pinch-off region and contact at a seam 19 where they pass over the pinch off region of each mould half. The mould halves 3 and 4 include complementary surfaces 10 and 11 respectively in the pinch-off region. Referring to Figure 2b the mould halves are brought further together to reduce the thickness of the contacted region of sheets 7 and 8 to a thickness substantially less than the combined thickness of the undeformed sheets. Material is thereby forced from the pinch-off region to form an internal reinforcement 12.

As illustrated in the drawings, in the present invention, one mould half, 4, incorporates a pinch-off region which is moveable relative to the remainder of that mould half in a direction away from the direction of travel of that mould half. In particular a pinch-off member 13 is disposed within a channel 14 in the mould half and

is held in its usual position by a spring 15 which is preferably pre-compressed so that a particular level of force against the member 13 must be applied before it will retract into the cavity 14. Thus in Figure 2b, although the moulds have been brought together close enough to compress the plastic material in the pinch off region and to extrude it from the pinch off region to provide a weld reinforcement with the join between the two sheets, the pinch-off member 13 has not yet been subjected to sufficient force to cause it to retract into the cavity 14. With the elastic support of the pinch-off member as depicted it is important that the mould halves are not brought together too quickly, which could result in sufficient dynamic forces to move the pinch-off member.

Alternatives to the member, spring and channel may readily suggest themselves, such as are mentioned below, however the configuration shown is simple, and provides for automatic actuation by the normal movement of the mould halves in the moulding process.

As mentioned above, there are many alternatives to the use of a pre-compressed spring. If a spring is used then, rather than being pre-compressed, an appropriate effect can be achieved using a spring of sufficiently high stiffness, or by separately retaining the spring against movement until reduced thickness has been achieved. As an alternative to a spring, hydraulic or pneumatic systems may be utilised either in a full sealed cavity configuration or with hydraulic or pneumatic actuators, which may make use of automated pressure relief valves, or valves activated in a separately controlled manner once the reduced thickness is reached. Similarly electrical or mechanical activation systems are also possible operating on a release and return basis.

Referring to Figure 2c the mould halves are then brought still closer. As the gap in the pinch off region narrows the force compression required to extrude further material from the cavity rises, particularly as the material cools in the region of its contact with the mould halves. Once the force being applied to the member 13 in the pinch-off region, by closing of the mould halves, exceeds the threshold set by the pre-compression of spring 15, the member 13 will retract into the cavity 14 with continued closing of the mould halves 3, 4. As illustrated in Figure 2c, a lip 16 being the edge of the cavity 14 will come to overlap into the cavity of the other mould half 3. In this manner the faces 17 of mould half 3 and 18 of mould half 4 will overlap with a close

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tolerance, and in doing so the respective edges will shear off the seam region 19 and other flanges 20 of the thermoformed article. To improve the finished edge of the thermoformed article, where the seam has been removed by the shearing action of the faces 17 and 18, the mould halves should be subject to a minimum horizontal tolerance to give an accurate maximum separation 21 between the faces 17 and 18. Ideally this separation would be non-existent, however in practice bringing the mould halves together without clashing between the edges 30, 31 of the mould halves requires provision of a small tolerance. The maximum separation of the edges which will still provide adequate surface finish is dependent on the material being thermoformed, its properties and its thickness, and also on the aesthetic requirements of the product being formed. A separation of 0.1mm has been found appropriate when thermoforming ABS plastics for use in domestic appliances. Alignment posts or other similar means may be provided to provide accurate horizontal registration between the mould halves as the mould halves come together, allowing the small tolerance to be achieved in a mass manufacture environment.

With reference to Figures 1 and 3, the pinch-off member 13 is subject to continued force from the spring 15, and is retained in the cavity against such spring force by a retaining means comprising in the embodiment depicted the action of an abutment 22 depending horizontally from the lower edge of member 13, against a ledge 23 provided in the channel 14. Assembly of the mould half in this manner may be easily provided by the inclusion of a sheath part 25 in the overall assembly.

Clearly alternatives to the abutment method of retention as described above are possible and many would suggest themselves to persons skilled in the art. For example, the pinch-off member may include two or more slotted apertures extending laterally there through, with dowels passing through the apertures and secured to the mould so that the pinch-off member may move up and down with the dowels moving within the slots, and with the movement of the pinch-off member being restricted by the action of the dowels against the slot ends. This configuration may allow for a more compact mould assembly method with machinery of a simple rectangular channel to retain the pinch-off member.

The present invention thereby provides thermoforming mould apparatus of

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simple form and actuation which allows both significant material displacement in the pinch-off region, and an effective and aesthetic cut-off or trimming of the formed article, without the use of separate knife actuation or other independently actuated parts. The forming and trimming of the part is accomplished in one action, leaving the part ready for removal, or for example foam filling while still in the mould. The requirement for manual part trimming or a separate automated trimming station (with its associated alignment and part set-up operations) is eliminated while the weld reinforcement is retained.

It will be appreciated that the level of material displacement achieved can be controlled by adjustment of the force provided by spring 15, and its pre-compression. As an alternative, and for set tolerancing, means may be provided whereby the member 13 is rigidly forced backwards when the required thickness is achieved, in which case the spring 15 may be happily left in an over-compressed state. Such means may comprise for example a plurality of pimples or ridges 28 on the top surface of the member 13, which act against the face 10 of the other mould half, penetrating or substantially penetrating the material being formed. The pimples or ridges or the like could also of course be disposed on the pinch-off surface 10 of the other mould half 3, or on both faces 10 and 11.

## CLAIMS:

1. A mould for twin sheet thermoforming wherein one of the mould halves includes a retractable pinch-off region, which is able to retract relative to the remainder of said mould half upon application of a force thereto greater than a predetermined force, such  
5 that the remainder of the mould half may cooperate with the second mould half, on further closing, to shear off the seam of a thermoformed article.
2. A mould for twin sheet thermoforming as claimed in claim 1 wherein said retractable pinch-off region comprises a pinch-off member generally retained within a channel and resiliently supported therein, such that the pinch-off member may retract  
10 into the channel so that the corner of the channel adjacent the mould cavity may cooperate with the corner between the pinch-off surface of the second mould half and the adjacent surface of the mould cavity of the second mould half to shear off the seam of the thermoformed article.
3. A mould for twin sheet thermoforming as claimed in claim 2 wherein said  
15 channel has a pre-compressed spring means therein, the pre-compression of the spring means determining the predetermined application force before retraction of the pinch-off member, and retaining means are provided to retain the pinch-off member within the cavity under pressure from said pre-compressed spring means.
4. A mould for twin sheet thermoforming as claimed in claim 2 wherein said  
20 resilient support of said pinch-off member comprises means which retract upon application of a sufficient force to the pinch-off member in either a passive or active manner.
5. A mould for twin sheet thermoforming as claimed in claim 3 wherein said  
25 retaining means comprise a ledge within said cavity, said pinch-off member having a cooperating shape to abut against said ledge and be retained in said channel by said ledge.
6. A mould for twin sheet thermoforming as claimed in claim 3 wherein said  
30 retaining means may comprise two or more slotted apertures in said pinch-off member, with dowels passing there through connected to the mould, allowing said pinch-off member to slide in said slotted direction on said dowels with the limitation of movement by said slots.



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7. A mould for twin sheet thermoforming as claimed in claim 3 wherein said pre-compression and/or stiffness of said spring means is carefully determined to achieve the requisite plastic displacement in the welded plastic material prior to retraction of the member.
- 5 8. A mould for twin sheet thermoforming as claimed in any one of claims 1 to 7 wherein stop means are provided which guarantee a set minimum separation between the pinch-off member and the other mould half pinch-off region before retraction of the pinch-off member.
9. A mould for twin sheet thermoforming as claimed in claim 8 wherein such stop  
10 means comprises ridges on the pinch-off member which penetrate the welded plastic material and contact the second mould half pinch-off region.
10. A mould for twin sheet thermoforming as claimed in claim 2 wherein the mould cavity and pinch-off member retaining channel are configured such that said cavity is very close to the mould cavity edge, and that the inner edge of the channel lies close to,  
15 but within, the outline of the mould cavity of the second mould half to overlap slightly therewith and cooperate to shear off the seam of a thermoformed article.
11. A method for producing a pre-trimmed twin sheet thermoformed article wherein a pair of mould halves are brought together to join respective sheets in a pinch-off region, and to cause significant thickness reduction in the pinch-off region, and  
20 subsequently causing the pinch-off region of one said mould half to retract relative to the rest of said mould half, to thereby allow said mould halves to close further, and closing said mould halves further to cooperate to cut off the seam of the thermoformed article.
12. A method as claimed in claim 11 wherein said joining, said thickness reduction  
25 and said causing said pinch-off region to retract are all accomplished by the closing of the said mould halves, with the movement of said pinch of region accomplished passively by pressure from the other mould half.
13. A method as claimed in claim 12 wherein said mould halves have cooperating edges at the edge of said seam region, one said edge being the edge of the mould cavity  
30 portion of a said mould half, which cooperate to shear off said seam of the thermoformed article.



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14. A plastic article manufactured in accordance with the method of claim 11.

15. A mould for twin sheet thermoforming including a pinch-off region substantially as herein described in accordance with and as illustrated by the accompanying drawings.

5 16. A method for producing a pre-trimmed twin sheet thermoformed article substantially as herein described with reference to and as illustrated by the accompanying drawings.

10 17. A plastic article manufactured in accordance with a method of twin sheet thermoforming substantially as herein described with reference to and as illustrated by the accompanying drawings.

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